September 4, 1978

Foreign Agriculture

Foreign
Agricultural
Service
U.S. DEPARTMENT
OF AGRICULTURE

Part of Peru's large anchovy fishing fleet.

United States
Department of
Agriculture

Food Safety
and Inspection
Service

Science

March 1987

Salmonella in Broilers and Overflow Chill Tank Water

1982-1984

RESULTS OF A NATIONAL SURVEY: SALMONELLA IN BROILERS AND OVERFLOW CHILL TANK WATER, 1982 - 1984

Stanley S. Green
Microbiology Division

SCIENCE
FOOD SAFETY AND INSPECTION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

MARCH 1987

The Microbiology and Field Service Laboratories completed a benchmark study to determine the incidence of salmonellae in whole broilers in 1979. This study was prompted in part by recommendations put forward by the U.S. Advisory Committee on Salmonella. Data obtained from the study were very valuable in that it indicated a national incidence of Salmonella in broilers of approximately 36 percent. The national incidence rate estimated in this study was comparable to the incidence rate seen in a previous 1967 study. In both these studies, only a small number of establishments and birds were sampled (compared to the 1982-84 study). The incidence rates on these studies were approximately 36 percent.

A statistically refined national study using a larger plant population from which to collect samples was devised with the cooperation of the Mathematics and Statistics Division. The sampling plan for the 1982-84 study had whole broilers chosen from probalistically selected groups of slaughter plants on a rotational basis. The probability of a plant being selected for a group was approximately proportional to production volume as of 1982. The rotation was such that plants when selected, were sampled once every 4 months within the year. Sample requests were made monthly. Three whole broilers and three chill tank waters were obtained for each sampling day.

Chill tank water was collected at the overflow point. Chlorine useage at the time of sampling was recorded. A whole bird rinse procedure was employed whereby the entire bird surface (interior and exterior) is rinsed with sterile medium. The total rinse fluid (approximately 100 ml) was used for analysis rather than a smaller aliquot. Chill tank water collected at the overflow site was included in the study to determine if there was a correlation between the incidence of salmonellae in whole broilers and the incidence of salmonellae in chill tank water and also to evaluate plant controls for Salmonella. Water samples were analyzed using four different volumes: 1 ml, 10 ml, 25 ml, and 100 ml.

One Salmonella isolate from each broiler and water sample were submitted to the Veterinary Services, National Animal Disease Laboratory, Ames, Iowa, for serotyping to obtain national information regarding Salmonella serovars in the United States broiler industry.

Results

A summary of incidence rates for the various types of samples are presented in Table 1. A positive for a water sample was recorded if any of the four volumes analyzed were positive for salmonellae.

The percentage of Salmonella incidence for a plant is weighted by the product of: plant production (during 1982) and the inverse probability of selection. The weighted percentage of positive broilers nationally is 35.8 percent, the unweighted is 35.2; for the water sample it is 44.4 and 45.5 respectively. Since the sample design selected larger plants with higher probability, the closeness of the weighted and unweighted percentages is expected. For ease of calculation, and reducing variance, unweighted values will be used in the subsequent analyses.

Using the pattern of positive results in the four volumes of chill tank water (1, 10, 25, 100 ml), a semi-quantitative measure of the number of salmonellae was calculated, as follows: if the 1 ml subsample were positive then the estimated number of salmonellae per 100 ml would be greater than or equal to 100; if the 10 ml subsample were positive and the 1 ml subsample were negative then the estimated number of salmonellae would be between 10 to 100; and so forth. By convention, if an inconsistency occurs in the pattern, that is, if the 1 and 25 ml subsamples are positive and the 10 ml subsample is negative then the assigned estimate is the middle (10-100/100 ml) value. Table 2 gives the distribution of the estimated number of salmonellae.

From the table it is seen, for example, that 79 percent of the samples are estimated to have less than 10 salmonellae per 100 ml of water.

Table 3 provides information on the number of occurrences of an inconsistency in the pattern. The table provides a cross tabulation of the estimated levels of salmonellae and the number of positive subsamples from each water sample. For example, there were 216 samples with two positives; 149 have no inconsistency in the pattern. The number of samples with no inconsistencies are given along the diagonal from upper left to lower right. Out of 640 samples for which there were between one and three positives, there were only 23 percent with an inconsistency. The total number of samples with an inconsistency is small, therefore, the estimates in Table 2 provide a good approximation of the levels of salmonellae in the chill tank water.

The design called for three corresponding water and bird samples per day of sampling. From among the days where all three samples were taken and analyzed, 35 percent had no positive water samples, 42 percent had no bird sample positives, and 27 percent had no positives in either birds or water samples. Table 4 presents information on the number of days for which there was at least one positive from among the

three bird and three water samples. This information as summarized in Table 4 only includes those days for which all samples were taken. The statistics provided is the number of establishments that had a specified number of days with at least one positive result in either a water or bird sample. Also provided is the expected number of establishments, assuming a binomial distribution, i.e., "pure" randomness of days with no positive, with the parameters: (a) the number of establishments sampled a specified number of days, and (b) the probability of a no positive day which was set equal to 27 percent.

An establishment effect would be evident if the entries on the top or bottom of Table 4 are greater than the expected values. This occurs, for example, in the cells representing establishments that had no days with at least one positive, for establishments sampled from 2 to 4 days, and also in the cell representing establishments sampled 6 days and had all days with at least one positive. The distribution of the values in this table indicates a slight tendency toward an establishment effect. The hypothesis that the data are distributed as a binomial (over establishments sampled from 2 to 6 days) would be rejected at the 0.01 significance level, using the usual chi-square test method, either by pooling over the number of days for which there were positives, or otherwise. However, the small sample sizes and expected numbers makes a definitive statistical conclusion somewhat tenuous though the dates tend in a manner consistant with there being an establishment effect.

Relation of *Salmonella* Incidence in Broilers and Chill Tank Water Samples

The questions answered in this subsection are:

(1) What is the relationship between positive broiler samples and positive water samples at various dilutions of water?

(2) Does the *Salmonella* incidence rate change as the production day progresses?

Answers obtained from the first question will be helpful in determining to what degree water samples can be used in place of bird samples for monitoring *Salmonella* in birds. The subsequent discussion below is oriented in this direction, that is, can observed incidence in water samples be used to predict incidence in bird samples? Because of the public health significance of *Salmonella*, the emphasis of the

analyses presented below is when water samples are negative and bird samples are positive. This occurrence will be termed a "negative event."

In the subsequent analyses for this subsection, all production days which did not have three bird samples or all designated water samples were deleted. This is to simplify analyses and interpretation.

Table 5 a-d consists of four charts whose entries are the percentage of the number of days for which there was: (1) no positive bird; no positive water; (2) no positive bird, at least one positive water; (3) at least one positive bird, no positive water; and (4) at least one positive bird, at least one positive water. Each chart corresponds to a different water volume tested. High percentages on the diagonal (upper left to lower right) are an indication of a high correlation between the incidence of salmonellae in broilers and water samples.

Computing the percentage of the number of times all water samples at a single dilution were negative on the same day when there were positive broiler samples, gives an indication of the relationship between Salmonella incidence in broilers and water. A high value indicates a poor relationship; for the 1 ml and 10 ml volumes the percentages are 78% and 52% respectively. These two values are considered high indicating a high probability of "negative event" for these volumes. The values are 29% and 19% respectively for the 25 ml and 100 ml water volumes indicating a better relationship.

A more in-depth analysis relating the number of positive broilers and water samples shows the relationship with the broiler incidence to the 25 and 100 ml water samples. Table 6 a-b show the relationship of positive water to the number of positive broilers. The entries in the tables are the number of production days for which samples were taken. In the table margins are the average number of positive bird or water samples for a given number of positive water or bird samples. The division of this average by 3 and then multiplied by 100 percent would give the percentage of positive samples.

A linear regression (best fit of a straight line, by least squares) of the average of positive water samples versus the number of positive broilers was computed. The intercept of this line can be interpreted as the percentage of times for which there are positive water samples and no positive broilers. For the 100 ml volume the intercept is 0.60, i.e., approximately 20 percent of the water samples would be

positive given no positive broilers among the three samples taken per plant. For 25 ml, the percent positive water would be 13%. On the other hand, from the regression line, the predicted value for three positive broilers provides an indication of the percentage of water samples that would be positive, given that all three broilers were positive for salmonellae. At the 25 ml water volume 62% would be positive i.e., 38% would be missed while 79% of the water samples at 100 ml would be positive. These numbers will be useful to determine the amount of water necessary to substitute for a broiler sample. The results indicate that the volume that most closely tracks incidence in broilers is between 25 and 100 ml, whereas the use of 25 ml water samples would provide a slight underestimate, and the use of 100 ml a slight overestimate. This corresponds with what would theoretically be expected. Assuming, for example, a 3 pound bird with 4 percent water pickup, the amount of water would therefore be approximately 55 ml.

Table 7 provides information relating the estimated levels of salmonellae in water samples and the positive rate in the companion broiler samples. As expected, the incidence rates for broilers increases as the estimated levels increase. For water samples with levels estimated to be below 1 per 100 ml, the percentage positives of the companion broiler samples was 19 percent; for water samples with estimated levels between 1-4, the percentage was 45 percent; for levels 4-100, the percentage was 54 percent; and for levels exceeding 100, the percentage was 69 percent.

As is evident, there is a substantial increase in the percentage once any volume of water indicated the presence of salmonellae. Among the water samples that were sampled on days when there was a positive bird sample and the corresponding water sample was negative, 49 percent were estimated to have levels less than 1 per 100 ml, 20 percent had levels estimated between 1-4, 20 percent between 4-10, 5 percent between 10-100, and 5 percent greater than or equal 100. Comparing these results with the results in Table 2, it is seen that the percentage of high level water samples is smaller for these samples.

Salmonella Incidence by Time of Day

Table 8 gives the percentage of *Salmonella* incidence by period of day for birds, and water volumes of 10 ml, 25 ml, and 100 ml. The "combined" heading counts the percentage of times any of the four water volumes were positive.

As is evident, a consistent pattern of increase of incidence occurs with time of day. The percentages are highest at 8 hours for all types of samples. Further, observe that the percentages for the 100 ml subsample though slightly higher, follow most closely the percentage of positive birds compared to the other water subsamples, with the exception of the 6 hours time frame.

Effect of Chlorine, Geographic and Time Frame (Months)

The 2 years of the survey can be divided into six 4 month periods, the first period covering from May to August 1982 inclusive. Table 9 provides the percentage of positive birds and combined water samples broken down by chlorine useage at the time of sampling, and by time frame.

The differences between the mean incidences for the classes for low and high chlorine uses are statistically significant at the 0.01 level, as would be expected. The statistical analysis was done using a weighted analysis of variance (AOV); the variable used in the AOV was the mean number of positive results per day of sampling.

Examination of Table 9 reveals a lower incidence for the plants using chlorine at the beginning of the survey (May - August 1982). After this period, the difference of incidence between plants using various levels of chlorine decreases. No explanation of the difference seen in the first period is available at this time.

The difference between time periods is explored further by considering only those plants sampled in the first period. Table 9 is similar to that of Table 9, except only results from those plants sampled in the first period are used.

The results from Table 7 indicate that a plant effect, per se, does not contribute to the lower observed incidence for the first period in plants using chlorine at 1 ppm or greater.

Another pattern noticed from Tables 9 and 10 is the higher incidence for the periods 2 and 5, i.e., the period between September and December. Using the Scheffe multiple comparison technique, this seasonal affect is statistically significant at the 0.10 level for water, and 0.05 level for birds (controlling for chlorine useage).

The incidence of Salmonella as a function of the chlorine level used was also investigated. Table 11 a-b presents the incidence of plants classified into groups by the amount of

chlorine use: group 1 <1 ppm; group 2, between 1 and 4 ppm; group 3, between 5 and 9 ppm; group 4, between 10 and 19 ppm, and group 5, greater than 19 ppm. As is evident, there is a decreasing pattern with increasing chlorine concentration. The decrease is also present when data from time frame 1 are excluded from the analysis.

The effect of chlorine on the incidence of Salmonella is statistically significant. Statistical analysis also revealed that the functional behavior can be adequately described, using a logit transformation on the incidence rate, and linearly relating this to the square root of the concentration. A logit transformation is the natural logarithmic transformation of the odds of a positive sample. Statistical analysis indicated that the functional shapes of the curves are similar for water and bird samples. Enclosed is a graph of the predicted percent incidence rate as a function of chlorine useage, for water samples and bird samples.

Table 12 examines the relation of region of country and use of chlorine and incidence of Salmonella. Most of the samples were collected from 3 regions of the country: Northeast, Southeast and Southwest. Because about one-third of the total variation is due to day of sampling, Table 12 presents the mean of the daily percentage positives, and the number of days sampled.

Regions

An analysis of variance was performed to determine the significance of the region effect controlling for chlorine level useage. Days of sampling were classified into one of three categories, depending on chlorine level added. The three categories are: less than 1 ppm, between 1 and 9 inclusive, and greater than 9. As a preliminary step, an analysis of variance was performed to determine variance components associated with the sampling of establishments and different days of sampling for a given establishment. Table 13 shows the results of this analysis.

A large part of the variance due to sampling is associated with the day of sampling. In the following analysis the percentage of positives and the number of observations were determined per day of sampling. An arcsin transformation was computed on the percentage positive. This transformation makes the underlying variance a function of only the number of samples used in determining the percentage. (That is, a basic assumption used in calculating the statistical significance levels is that the underlying variance is

constant. The validity of the resulting inferences are not effected much by a slight relaxation of this assumption, however, using this type of transformation makes the assumption true, and thus, the calculations more accurate). A weighted (to the number of observations) analysis of variance was performed with region and Cl concentration categories as fixed effects, and no interaction term. The results of this analysis indicate that the difference in incidence between the Southwest Region and the average of the Southeast and Northeast is statistically significant at the 0.10 level for water samples and the 0.05 level for broiler samples. Ninety percent confidence intervals of the difference on the percentage incidence using the Scheffe method of multiple comparisons (which provides the longest intervals compared to most other procedures) were computed. The differences were estimated controlling for category of chlorine concentration, that is, the estimates are averages that would be obtained if the number of observations were balanced over the categories. The above analysis was repeated with the change that percentages were computed within an establishment (pooling over days of sampling), rather than within a day of sampling. The results do not substantially change, as is evident in Table 14.

Culture Types

About half the positive samples were analysed further to identify the Salmonella serotype. The serotypes with less than 20 in number were grouped together. A chi-square test for the difference between the water and bird distributions was insignificant ($P = 0.50$), indicating that for practical purposes the distributions could be considered the same. Differences in the distribution of serotypes between regions were investigated. Table 15 presents the number and percentage found in the specified region of the specified serotype. The differences between the distributions amongst the three regions are not substantial.

Further investigated was the pattern of serotypes found within establishments. As expected there was a high degree of clustering of serotypes within a day of sampling. For example, consider the serotype "Heidelberg," which was approximately 25 percent of all serotypes identified. An analysis of variance on the incidence of this serotype was performed, i.e., a value of 1 was assigned if the serotype was "Heidelberg" and 0 if another serotype was found. Table 16 gives the results of this analysis.

Thus a large part of the variation is between establishments and day of sampling. However, since not all positive samples

were identified as to Salmonella serotype, conclusions drawn from these data must be carefully considered.

Conclusions

The results from this survey provide the following useful information:

1. The data from this study indicate that incidence rates from water samples from between 25 - 100 ml in volume would serve as a good substitute for incidence rates in broilers. Since the collection and shipment of water samples is cheaper than that of broiler samples, using water as a sampling source for future monitoring programs may provide a substantial saving. Such a saving could be an incentive for industry monitoring purposes.

2. The incidence rate of salmonellae increases as the day progresses. Therefore, in order to monitor national trends, the time of day of sampling is an important design factor.

3. There is an effect of chlorine on the incidence rates. For establishments using little or no added chlorine, the incidence rate in broilers was estimated to be approximately 38% and the rate decreases to a level of about 28% for establishments adding 20 or greater ppm chlorine. While the decrease is statistically significant, the magnitude is not large. However, it is encouraging in that it documents that a single control process can reduce the incidence in Salmonella by approximately 25%.

4. The Southwest region had the lowest incidence rate from among the Southwest, Southeast and Northeast regions. The difference between the incidence of salmonellae in broilers in the Southwest and the average incidence in the other two regions was statistically significant at the 0.05 level. (See Tables 12 and 14)

5. The distribution of serotypes from water samples and broilers were very similar. The statistical test used to determine a significant difference between distributions had a significance level of 0.50. Serotypes were clustered within day of sampling as would be expected.

6. More than 1/2 the water samples were negative, thus, indicating less than one salmonellae per 100 ml of water, and 79 percent of the water samples were estimated to contain 10 salmonellae or less per 100 ml of water. This indicates that the great majority of the samples contain few salmonellae.

Among the negative water samples, the companion broiler samples were positive 19 percent of the time. On water samples for which the estimated level of salmonellae was between 1-4 per 100 ml, 45 percent of the companion broiler samples were positive; for samples with levels between 4-100 per 100 ml, 54 percent of the broilers were positive; and for samples with levels greater than 100 per 100 ml, 69 percent of the broiler samples were positive (Table 7).

The above statistics confirm the ability of water samples to be used as an effective substitute for bird samples for the purposes of monitoring and determining trends in salmonellae occurrence. They also indicate that the degree of *Salmonella* contamination in terms of the numbers of contaminating cells is very low. This observation improves optimism that additional control procedures may be effective in reducing the incidence of *Salmonella* in broilers.

Table 1. Percent Incidence of Salmonellae in Whole Broilers and Various Volumes of Chill Tank Water by MPIO Region (1982 - 1984)

	MPIO REGIONS					
	W	SW	NC	SE	NE	NATIONAL
No. Broilers Analyzed	48	417	23	943	270	1719
% Positive	17.6	25.5	34.8	38.3	43.3	35.2
Water Samples*						
1 ml	8	4.9	12.5	7.3	14.0	7.7
10 ml	16	15.0	33.3	20.5	26.2	19.9
25 ml	18	24.3	37.5	30.4	35.7	29.3
100 ml	30	32.8	54.2	41.7	48.9	40.3
Combined	30	39.3	58.3	46.4	55.2	45.5
Number of Chill Tank Water Samples Analyzed	50	412	24	888	221	1595

* Water Samples Collected at Overflow

Table 2. Distribution of Estimated Numbers of *Salmonella* Per 100 ml Chill Tank Water

Salmonella Levels/100 ml	No. of Samples	Percent	Cumulative Percent
<1	870	54.5	54.5
1 - 4	190	11.9	66.5
4 - 10	192	12.0	78.5
10 - 100	221	13.9	92.4
>100	122	7.6	100.0

Table 3. Tabulation of Positive Water Subsamples and Estimated Numbers of *Salmonella* Per 100 ml

Number of Positive Water Samples	<1	1-4	4-10	10-100	>100	
0	870	0	0	0	0	
1	0	190	43	16	2	
2	0	0	149	56	11	
3	0	0	0	149	24	
4	0	0	0	0	85	
Total	870	190	192	221	122	1,595

Table 4. Number of Days at Least One Positive Result Found Amongst the Three Water and Three Bird Samples

Number of Days Sampled

No. of Days at Least One Positive	1	2	3	4	5	6	7	8	9
0	8* (9.5)**	3 (1.5)	1 (0.5)	1 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
1	27 (25.5)	9 (8.3)	4 (3.8)	2 (1.4)	0 (0.4)	1 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)
2		9 (11.2)	8 (10.4)	4 (5.6)	4 (1.9)	0 (0.7)	0 (0.1)	0 (0.0)	0 (0.0)
3			11 (9.3)	11 (10.1)	7 (5.1)	2 (2.5)	0 (0.3)	1 (0.1)	0 (0.0)
4				6 (6.8)	4 (6.9)	2 (5.0)	0 (0.8)	0 (0.2)	0 (0.0)
5					3 (3.7)	3 (5.4)	0 (1.3)	0 (0.5)	0 (0.1)
6						8 (2.4)	2 (1.1)	1 (0.6)	1 (0.3)
7							2 (0.4)	0 (0.5)	0 (0.3)
Number of Plants - 145	35	21	24	24	18	16	4	2	1

Assuming a Binomial Distribution, the Probability of all Negatives in a Day is 27 Percent

* Number of Establishments

** ( ) Expected Number

Table 5 (a-d). Percent Incidence by Day of *Salmonella* in Whole Broilers Versus Chill Tank Water Volumes

5a. 1 ml water

Bird	1 or More Positive	All Negative	% Bird Incidence by Day
1 or More Positive	13%	45%	58%
All Negative	2.7%	39%	42%
% Water Incidence By Day	16%	84%	

5b. 10 ml water

Bird	Positive	All Negative	% Bird Incidence by Day
Positive	28%	30%	58%
All Negative	6.7%	35%	42%
% Water Incidence By Day	35%	65%	

Table 5 (continued)

5c. 25 ml water

Bird	Positive	All Negative	% Bird Incidence by Day
Positive	42%	17%	58%
All Negative	8.4%	33%	42%
% Water Incidence By Day	50%	50%	

5d. 100 ml water

Bird	Positive	All Negative	% Bird Incidence by Day
Positive	47%	11%	58%
All Negative	13%	29%	42%
% Water Incidence By Day	60%	40%	

Table 6 a-b. Relationship of *Salmonella* Positive Water Samples to *Salmonella* Positive Broilers and Production Days

6a. 25 ml water

Water		0 Pos.	1 Pos.	2 Pos.	3 Pos.	Average No. of Positive Water Samples
Birds No. Pos.	Total Days					
0	199	159	24	10	6	0.31
1	124	50	42	20	12	0.95
2	87	17	28	27	15	1.46
3	67	13	14	15	25	1.78
Average No. of Birds Positive		0.51	1.30	1.66	2.02	
Total Days	477	239	108	72	58	

Table 6 (continued)

6b. 100 ml water

Water		0 Pos.	1 Pos.	2 Pos.	3 Pos.	Average No. of Positive Water Samples
Birds No. Pos.	Total Days					
0	199	138	30	22	9	0.51
1	124	35	37	28	24	1.33
2	87	11	20	23	33	1.90
3	67	6	10	14	37	2.22
Average No. of Positive Birds		0.39	1.10	1.33	1.95	
Total Days	477	190	97	87	103	

Table 7. Incidence Rates in Broiler Samples, Compared with Estimated Levels of *Salmonella* in Companion Water Samples

Estimated Level (Water	Percent Incidence (Birds)
<1/100 ml	19
1-4/100 ml	45
4-10/100 ml	53
10-100/100 ml	55
>100/100 ml	69

Table 8. Percent Incidence of *Salmonella* in Whole Broilers and Chill Tank Water as Related to Hours of Plant Operation*

Time of day	Birds	10 ml	25 ml	100 ml	Combined
(1) 4 hrs	34	17	28	37	43
(2) 6 hrs	34	21	31	42	47
(3) 8 hrs	39	23	31	44	50

* Samples collected 4, 6, 8 hours after start up.

Table 9. <u>Salmonella</u> Incidence in Broiler and Water Samples by Time Period and Chlorine Useage

	Chlorine Levels					
	<1 ppm		1-9 ppm		>9 ppm	
Months/Yr	Broiler	Water	Broiler	Water	Broiler	Water
May-Aug 82	36 (141)*	44 (135)	11 (46)	10 (40)	16 (38)	17 (35)
Sept-Dec 82	45 (150)	53 (140)	46 (65)	65 (55)	14 (56)	28 (46)
Jan-Apr 83	32 (156)	45 (148)	28 (81)	43 (76)	50 (36)	28 (32)
May-Aug 83	33 (127)	37 (118)	29 (75)	54 (69)	33 (49)	33 (45)
Sept-Dec 83	48 (174)	53 (166)	44 (71)	56 (70)	37 (51)	34 (41)
Jan-Apr 84	29 (139)	49 (136)	33 (54)	47 (51)	19 (59)	33 (57)
Mean	38 (887)	47 (843)	33 (392)	48 (361)	27 (289)	30 (256)

* ( ) Sample Size

Table 10. Percent Incidence of *Salmonella* in Broilers and Water Samples: Plants Sampled in First Period

	Chlorine Use			
	<1 ppm		>1 ppm	
Months/Yr	Bird	Water	Bird	Water
May - Aug 82	36	44	11	13
Sept - Dec 82	53	48	38	50
Jan - Apr 83	33	49	33	39
May - Aug 83	38	41	32	37
Sept - Dec 83	43	59	41	46
Jan - Apr 84	31	48	29	50

INCIDENCE OF SALMONELLA IN WHOLE BROILERS AND CHILL TANK WATER SAMPLES AS A FUNCTION OF CHLORINE CONCENTRATION

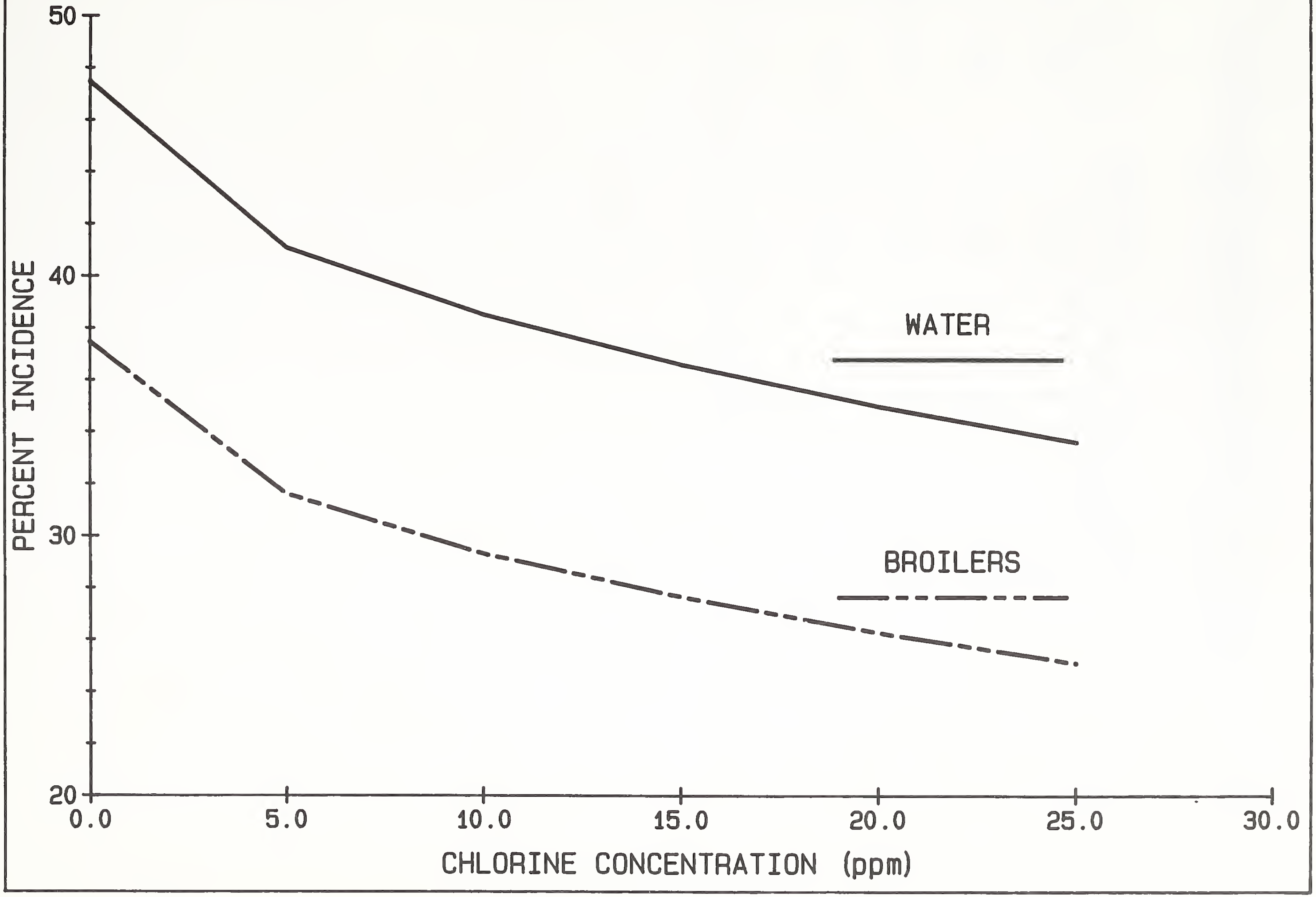

Table 11a. Percent Incidence of *Salmonella* in Whole Broilers and Chill Tank Water as a Function of Chlorine Concentration

Group	Bird No. of Samples	Bird Percent	Water No. of Samples	Water Percent
<1 ppm	887	38	843	47
1-4 ppm	346	30	318	45
5-9 ppm	49	49	46	67
10-19 ppm	93	28	83	24
>19	199	26	175	32

Table 11b. Percent Incidence of *Salmonella* in Whole Broilers and Chill Tank Water as a Function of Chlorine Concentration Excluding the First Time Frame (May - Aug 1982)

Group	Bird No. of Samples	Bird Percent	Water No. of Samples	Water Percent
<1 ppm	746	38	708	48
1-4 ppm	304	33	281	49
5-9 ppm	45	53	43	72
10-19 ppm	84	27	74	26
>19	170	29	149	34

Table 12. Estimated Percent Incidence of *Salmonella* in Broilers Water Samples by MPIO Region and Chlorine Concentration

Region	Chlorine	Bird	No. of Days Sampled	Water	No. of Days Sampled
Southwest	<1 ppm	27	96	42	95
	1-9 ppm	18	19	38	19
	>10 ppm	23	23	26	22
Southeast	<1 ppm	44	150	46	147
	1-9 ppm	33	97	49	94
	>10 ppm	22	46	27	44
Northeast	<1 ppm	41	47	58	45
	1-9 ppm	42	11	52	7
	>10 ppm	43	23	43	18

Table 13. Analysis of Variance (Data for Regions 3, 5, and 6) Entries are Variance Components)

	Broilers	Water
Est. (Reg., Cl Conc.)	0.023	0.021
Day (Est., Reg., Cl Conc)	0.058	0.101
Remainder	0.144	0.125

Table 14. Confidence Intervals Between Southwest and Other Two Regions

Procedure of Computing	Broiler	Water
Within Day	5.2% to 24.5%	-0.7% to 20.9%
Pooling Day	4.6% to 25.6%	-1.8% to 22.1%

Table 15. Distribution of Serotypes Among Region, (Combined) Broiler - Water

Table of Serotypes by Region
Serotype
Frequency

Percent Within Region	SW	SE	NE	Total
Agona	19 8.76	24 6.15	4 3.48	47 6.51
Haardt	12 5.53	16 4.10	11 9.57	39 5.40
Heidelberg	63 29.03	93 23.85	22 19.13	178 24.65
Infantis	12 5.53	21 5.38	5 4.35	38 5.26
Kentucky	2 0.92	16 4.10	4 3.48	22 3.05
Mbandaka	5 2.30	14 3.59	5 4.35	24 3.32
Schwarzengrund	12 5.53	16 4.10	2 1.74	30 3.88
Senftenberg	11 5.07	15 3.85	2 1.74	28 3.88
Typhimurium	14 6.45	40 10.26	24 20.87	78 10.80
Remainder	67 30.88	135 34.62	36 31.30	238 32.96
Total	217	390	115	722

Table 16. Analysis of Variance on the Incidence of Serotype Heidelberg

Component	Estimate
EST (Reg.)	0.09
Date (Est.)	0.09
Remainder	0.10

ACKNOWLEDGEMENTS

The authors acknowledge the following persons for their extensive planning, guidance, laboratory analysis and sample collections.

MICROBIOLOGY DIVISION, SCIENCE

Ralph W. Johnston, Director
Jerry M. Carosella, Deputy Director
Alice B. Moran, Branch Chief
Nancy L. LaFon, Secretary

FIELD SERVICE LABORATORIES DIVISION, SCIENCE

Neal J. Whitney, Director
George Krumm, MIC, Eastern Laboratory
Jane Evans, Microbiologist
Joseph Chiu, MIC, Western Laboratory
Paul Uhler, Microbiologist
James Eye, MIC, Midwestern Laboratory
Mark Pratt, Microbiologist

MATHEMATICS AND STATISTICS DIVISION, SCIENCE

Bert Levy, Director
Harry Marks, Mathematical Statistician

MEAT AND POULTRY INSPECTION OPERATIONS

W. S. Horne, Acting Deputy Administrator
C. M. Seymour, Assistant Deputy Administrator

The multitude of regional inspection officials and plant inspectors whose conscientious and careful efforts in collecting and shipping these samples provided the keystone support to this project.

☆U.S. Government Printing Office : 1987 - 180-917/60325